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OF THE METHOD OF RENDERING VERY SENSIBLE THE Weakeſt Natural or Artificial Electricity.

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Read at the ROYAL SOCIETY, March 14, 1782.

LONDON:
Printed by J. NICHOLS.
MDCCLXXXII.

BRITISH MUSEUM

ON THE METHOD, &c.

PART I.

1. IT will be readily allowed, that an apparatus capable of rendering perceptible, or, as it were, of magnifying the ſmalleſt, and otherwiſe unobſervable, degrees of natural as well as artificial electricity, is of great advantage to the ſcience of electricity in general, and eſpecially for the inveſtigation of atmoſpherical electricity, which by this means may be rendered very ſenſible and conſpicuous when it is not to be diſcovered by common atmoſpherical conductors. This method is founded upon a particular uſe of my *electrophorus*, which is a machine well known to electricians.

2. Whenever in obſerving the atmoſpherical electricity no degree of it can be diſcovered by the ordinary methods of performing thoſe experiments, it is difficult to determine whether any electricity at all does or does not exiſt in the atmoſphere at thoſe times; ſince it may exiſt, and the quantity of it only be ſo ſmall as not to affect the electrometers employed. An ordinary conductor, erected in the beſt manner for the purpoſe of obſerving the atmoſpherical electricity, when the ſky is free from electrical clouds, ſeldom or never ſhews any ſigns of electricity. In that caſe, therefore, if we rely upon the common electrometers, even the moſt ſenſible, we muſt conclude, that neither the conductor nor the atmoſphere, ſo high as the conductor reaches, contains any electricity; but by means of the apparatus I am going to deſcribe, it will be found, that the ſaid conductors are never entirely void of electricity,

tricity, and it muſt be conſequently concluded, that the air, which ſurrounds them, is alſo at all times electrified. This method not only ſhews the exiſtence of electricity, but gives alſo room to aſcertain whether it is poſitive or negative, and that when the atmoſpherical conductor itſelf is not capable of attracting the fineſt thread; but if the conductor were to ſhew any very ſmall attraction, then, by means of our apparatus, there may be obtained even ſtrong ſparks.

3. The electrophorus in this caſe might perhaps better deſerve the name of *electrometer*, or *micro-electrometer*, but I had rather call it a *condenſer of electricity*, for the ſake of uſing a word which expreſſes at once the reaſon and cauſe of the phenomena to be treated of in this paper, as will be made evident in the ſecond part.

The whole method may be reduced to the following few obſervations. I. An electrophorus muſt be procured, the reſinous coat of which muſt be very thin, and either not at all electrified, or, if electrified, its electricity be entirely extinguiſhed.

II. Its uſual metal plate muſt be laid upon this reſinous and unelectrified plate, in full and flat contact; but care muſt be taken that it does in no point touch the lamina of metal upon which the reſinous ſtratum is uſually faſtened.

III. Thoſe plates being ſo conjointly placed, a conducting communication, *viz.* a wire muſt be brought from the atmoſpherical conductor to touch the metal plate of the electrophorus, and to touch that only.

IV. The apparatus muſt be left in that ſituation for a certain time, *viz.* till the metal plate may have acquired a ſufficient quantity of electricity through the conducting communication, which brings it from the atmoſpherical conductor very ſlowly.

V. Laſtly, the conducting communication muſt be removed from the contact of the metal plate: the metal plate is then ſeparated from the reſinous one, by lifting it up by its inſulating handle, after which it is in a ſtate of attracting, of electrifying an electrometer, or, if the electricity is ſufficiently ſtrong, of giving ſparks, &c. at the ſame time the atmoſpherical conductor itſelf ſhews either no electricity at all, or exceeding ſmall ſigns of it.

4. It was mentioned above (IV.) that the conducting wire muſt be left in contact with the metal plate *for a certain time*, the length of which, however, is not eaſily determined, ſince it depends upon variable circumſtances. When the conductor itſelf ſhews no ſigns of electricity, then it will be neceſſary to leave the apparatus, as directed above, during eight, ten, or more minutes. But if the conductor itſelf is capable of juſt attracting a very ſmall thread, then it will be ſufficient to leave the apparatus in contact as above mentioned, for a few ſeconds only, in order afterwards to obtain from it very conſpicuous electrical appearances.

5. Reſpecting the conducting communication between the atmoſpherical conductor and the metal plate, care ſhould be taken that it be made of the feweſt joints poſſible, or rather of one piece, ſince the difficulty of tranſmitting very ſmall quantities of electricity is conſiderably increaſed by every interruption, and it may thereby be quite obſtructed, as is often the caſe when a chain is uſed for that purpoſe.

6. As for the electrophorus to be uſed, it muſt be farther remarked, firſt, that its being very thin, as mentioned above, is of great importance; it having been obſerved, that the thinner the reſinous ſtratum is, the greater quantity of electricity can be accumulated into the metal plate laid upon it; which is the caſe whether the electricity is brought to it from the atmoſphere, as in the abovementioned inſtance, or from any other electric power. The thickneſs of one-fiftieth of an inch, or that of a common coat of varniſh, is very proper; whereas if the reſin was an inch thick or more, the experiments would anſwer very badly.

7. Secondly, the ſurface of the reſinous ſtratum, as well as the under ſurface of the metal plate, muſt be as plain and as ſmooth as poſſible, in order that the two ſurfaces may coincide more perfectly when laid one upon the other. It is well known how much this circumſtance favours the effect of the electrophorus; for this reaſon, in my publication on that inſtrument,

I recommended it as a thing eſſential to obſerve*: but this circumſtance is ſtill more eſſential when the ſame apparatus is to ſerve as a *condenſer* of electricity.

8. Laſtly, it deſerves to be repeatedly and particularly obſerved, that the reſinous plate, when it is to be uſed for our experiment, ſhould be quite free from any the leaſt electricity, otherwiſe the experiments cannot be depended upon. If, therefore, the reſinous plate has been excited before, ſo as to remain in ſome meaſure electrified, all poſſible care ſhould be taken to deprive it of that electricity, which however is not eaſily done. The moſt effectual method of doing it to expoſe the reſinous plate to the hot rays of the ſun or to the fire, ſo that its ſurface may be ſlightly melted, by which means it will entirely loſe its electricity †. The flame of a candle, or of a piece of paper, will eaſily deprive the reſin of its electricity, if its ſurface be paſſed over the flame. In order to obſerve whether the reſinous plate is quite free from any electricity, the metal plate muſt be laid upon it, there it muſt be touched with a finger, and afterwards, being lifted up after the uſual manner, it muſt be preſented to a fine hair; for if the hair is not attracted, you may conclude, that the reſinous plate has no electricity, and conſequently the apparatus is fit to be uſed as a *condenſer* of electricity.

9. Were I aſked, to what degree the electricity might be condenſed, or how much the electrical phenomena could be

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* See the two letters addreſſed to Dr. PRIESTLEY, and publiſhed in the *Scelta d'Opuſculi intereſſanti* of Milan for the year 1775.

† It has been believed for a long time, that to heat, and eſpecially to melt, ſulphur and reſins, was ſufficient to excite in them ſome electricity; but except the tourmalin and ſome other ſtones, which are really excited by heat alone, the reſins and ſulphur never become electrified by that means, except when they have by ſome means or other ſuffered any friction. The miſtake, as Father BECCARIA obſerved, was occaſioned by this, *viz.* that even the leaſt friction of the hand, or other body, is ſufficient to excite ſuch ſubſtances in thoſe favourable circumſtances; without which friction, thoſe ſubſtances, melted and left to cool by themſelves, are ſo far from acquiring any electricity, that they loſe every veſtige of it in caſe they were excited before the fuſion, as may be eaſily proved by experiment: nor ought this to appear wonderful, ſince fuſion or a ſtrong degree of heat renders every body a conductor of electricity.

increaſed by this apparatus; I would anſwer, that it is not eaſy to be determined, as it depends upon various circumſtances; however, *cæteris paribus*, the augmentation is greater in proportion as the body which ſupplies the metal plate with the electricity has a greater capacity, and is larger in proportion as the electricity is weaker. Thus we obſerved above (§ 2. and following) that if the atmoſpherical conductor has barely power enough to attract a very fine thread, it is nevertheleſs capable of infuſing ſuch a quantity of electricity into the metal plate of the electrophorus, as to let it not only actuate an electrometer, but even dart ſtrong ſparks. But if the electricity of the atmoſpherical conductor is ſo ſtrong as to afford ſome ſparks, or to let the index of the electrometer riſe to five or ſix degrees, then the metal plate of the electrophorus, which receives the electricity from this conductor, according to our method, will certainly let the index of the electrophorus riſe to the higheſt degree, and will give a ſtronger ſpark, yet it may be plainly perceived, that the condenſation is proportionably leſs in this than in the other caſe. The reaſon is, becauſe the electricity cannot be accumulated beyond the greateſt degree, *viz.* when the electricity is increaſed ſo much as to be diſſipated every way. Therefore, according as the electric power, which ſupplies the condenſer, is neareſt to the higheſt degree, the condenſation is proportionably leſs: but in that caſe there is no need of a condenſer, ſince its principal uſe is to collect and render ſenſible that ſmall quantity of electricity, which would otherwiſe remain imperceptible and unobſerved.

10. Whenever, therefore, the atmoſpherical conductor by itſelf gives ſufficiently ſtrong ſigns of electricity, then there is no occaſion to uſe our condenſing apparatus. Beſides, when the electricity is ſtrong, it often happens, that part of the electricity of the metal plate is impreſſed upon the reſin, in which caſe the apparatus acts as an electrophorus, and conſequently is unfit for our purpoſe (§ 8.).

11. In order to avoid ſuch an inconvenience, I have thought of ſubſtituting to the reſinous plate a plane, which ſhould not be a perfect electric, or quite impervious to electricity, but which ſhould be an imperfect conductor, ſuch as might hinder, in a cer-

tain meaſure only, the free paſſage of the electric fluid through its ſubſtance. There are many conductors of this kind; as, for inſtance, a clean and dry marble ſlab, a plate of wood (likewiſe clean and very dry, or covered with a coat of varniſh, or wax) and the like. The ſurface of thoſe bodies does not contract any electricity, or if any electricity adheres to them, it vaniſhes ſoon, on account of their ſemi-conducting nature; for which reaſon they cannot anſwer the office of an electrophorus, and therefore are more fit to be uſed as condenſers of electricity.

12. Beſides the advantages above mentioned, there is another, which ariſes from ſubſtituting an imperfectly conducting plane to the reſinous plate, namely, that the metal plate laid upon one of theſe does actually condenſe or acquire a greater quantity of electricity than when laid upon the reſinous plate, or other perfect electric; for ſince, as was ſaid above, § 6. the thinner the reſinous ſtratum is, the better it anſwers our purpoſe; in the caſe of a varniſhed or waxed board, this ſtratum becomes exceedingly thin, and it becomes nothing when an imperfectly conducting ſubſtance is uſed, ſuch as a marble ſlab, a very dry piece of wood, &c.

13. On the other hand, care ſhould be taken, in chooſing the above mentioned plane, that it be not too much of a conducting nature, or capable of becoming ſo in a very ſhort time, it being quite neceſſary, that the electricity ſhould find a conſiderable degree of reſiſtance in going through its ſubſtance. In chooſing, or in preparing, ſuch a plane by drying, or otherwiſe, it is better to render it too near to than too far from the nature of a non-conductor. A marble ſlab, or a board properly dried, anſwers admirably well, and is preferable to any other plane: otherwiſe the reſinous plate of an electrophorus is preferable to a common table or marble ſlab not prepared; for theſe bodies, being in ſome meaſure imbibed with moiſture, conduct much better than is neceſſary.

14. To be more particular, I ſhall add, that for this purpoſe it is better to uſe a flat piece of marble, and to grind it againſt the metal plate, till they coincide ſo well as to ſhew a ſenſible coheſion between them. Afterwards the piece of marble ſhould be expoſed for ſeveral days to the

heat of a warmed place, ſuch as an oven, a chimney, &c. in order to expel the moiſture, and to render it quite fit for our experiments (§ 12. 13.). The marble, thus prepared, will continue dry for a conſiderable time, except it be long expoſed to very damp air. As for the ſmall quantity of moiſture which the marble may accidentally and ſuperficially attract, it may be removed by expoſing it to the ſun, or to a fire, or even by wiping it with a dry and clean cloth, previous to the performing of experiments.

15. It is not every ſort of marble that will anſwer equally for this purpoſe. The old marbles, which have been long preſerved in dry places, anſwer better than thoſe which have been recently dug from the quarry. The difference of the ſpecies of marble is alſo of conſequence in this buſineſs; I have found ſome marbles which, without any preparation, anſwer vaſtly well, whereas others will not do near ſo well, even when properly prepared; excepting, however, when they are preſerved hot during the experiment; for, in that caſe, they anſwer better than the beſt pieces of marble that are not preſerved hot. It is always advantageous to warm the marble previous to the experiment.

16. Inſtead of preparing the piece of marble by a long continued heat, it will be ſufficient to give it a coat of copal varniſh, or amber, or lac varniſh: after which it muſt be kept in an oven for a ſhort time. By this means even the worſt ſort of marble anſwers very well, even without previouſly warming or keeping it hot during the experiment.

17. By means of the varniſh even a metal plate may be uſed inſtead of the marble. This ſhould be firſt made flat by grinding it againſt the upper plate, and then it muſt be varniſhed, but rather thicker than when the varniſh is laid upon the marble. In this caſe both the plates might be varniſhed, though it is ſufficient to varniſh one of them.

18. Here it may be ſaid, that in fact we are returned to the electrophorus. This is true; and indeed the varniſhed metal, or marble, or wood, may be excited by a very ſlight friction, even ſometimes by the ſimple laying of the metal plate upon it,

eſpecially when they are hot; hence there is no occaſion to warm them, when they are good for the purpoſe, leſt they ſhould be ſo well prepared as to be eaſily excited, and then act like an electrophorus.

19. However, the advantages which a varniſhed plate has above the common electrophorus are, 1. that the varniſh is always thinner than the common reſinous ſtratum of an electrophorus. 2. That the varniſh acquires a more ſmooth and plain ſurface; hence the metal plate may be more eaſily, and to more advantage, adapted to it.

20. Inſtead of the above mentioned plane of marble or metal varniſhed, there may be ſubſtituted, with equal advantage, any ſort of plane covered with dry and clean oil-cloth or oil-ſilk or ſattin and other ſilk-ſtuff that is not conſiderably thick; which will anſwer very well, without requiring any more than perhaps a ſlight warming. The ſilk-ſtuffs anſwer better for this purpoſe than thoſe made of cotton or wool, and theſe better than linen. However, by a previous drying and keeping them hot during the experiment, paper, leather, wood, ivory, bone, and every ſort of imperfect conductor, may be made to anſwer to a certain degree.

21. If thoſe imperfectly conducting ſubſtances were dried too much, then they would become quite electrics, and conſequently uſeleſs for our purpoſe (as will be made appear better in the ſecond part of this paper), excepting when they were uſed like reſins, &c.

22. I muſt not omit to mention alſo, that the apparatus may be rendered more ſimple by applying the ſilk or other ſemi-conducting ſtratum to the upper, *viz.* to the metal plate, which is furniſhed with a glaſs handle inſtead of the marble or other plate, which in that caſe becomes uſeleſs: for in its ſtead a plane of any kind may be uſed, ſuch as a common wooden or marble table, even not very dry, a piece of metal, a book, or other conductor, whether perfect or imperfect, it being only neceſſary that its ſurface be flat.

In fact, nothing more is requiſite for our experiment than that the electricity, which tends to paſs from one ſurface to the other, ſhould find ſome reſiſtance or oppoſition in either of the ſurfaces, as will be made more evident in the ſecond part. It is immaterial whether the non-conducting or ſemi-conducting ſtratum be laid upon one or the other of the planes, it being only neceſſary that they ſhould coincide very well together, which cannot be eaſily obtained when a common table is uſed for one of the planes, which is the only reaſon why it is better to uſe two planes which have been worked flat by grinding one upon the other, and one of them varniſhed, &c. A ſingle metal plate, covered with ſilk, with three ſilk ſtrings faſtened to it by way of a handle, may be conveniently uſed for ordinary experiments.

23. Hitherto we have conſidered the uſe of our condenſer in exploring the weak atmoſpherical electricity, which is brought down by the atmoſpherical conductor*. But this, though the principal, is not the only uſe to which it may be applied. It ſerves likewiſe to diſcover the artificial electricity when this is ſo weak as not to be diſcoverable by any other means, which happens in various caſes, ſome of which I ſhall now proceed to mention.

24. A Leyden phial charged, and then diſcharged by touching its coated ſides three or four times with the diſcharging rod, or the hand, ſeems to be quite deprived of electricity, yet

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* Here it will be proper to mention a remarkable obſervation, which I have made on the atmoſpherical electricity with the help of the *condenſer*. The late Mr. CANTON and others affirmed that they had obtained ſtronger ſigns of electricity from their atmoſpherical apparatus at the time of an *aurora borealis*, than at other times; but various other philoſophers doubted of the influence of electricity in that meteor, and ſome abſolutely denied it. I myſelf was much in doubt about it; but at preſent Mr. CANTON's aſſertion ſeems to be eſtabliſhed beyond a doubt, as Ihave obſerved by actual experiment. During the ſtrong *aurora borealis*, which appeared in the night of the 28th of July, 1780, the light of which riſing gradually from the horizon, reached the zenith at near eleven o'clock, and enlightened the heavens with a reddiſh light, the weather being clear and windy; our condenſing apparatus being applied to an atmoſpherical conductor, gave fine bright ſparks; whereas, at other times, that is, in clear weather, and at every hour of the day or night, the ſame apparatus afforded either no ſparks at all, or exceedingly ſmall ones, the reaſon of which was becauſe the ſaid conductor was not much elevated.

if you touch with the knob of it the metal plate of our condenſer, when properly ſituated (*viz.* upon an imperfectly conducting plane, &c.) and immediately after take up the ſaid plate, this will be found to give very conſpicuous ſigns of electricity, which ſhews that the Leyden phial is not quite deprived of electricity as it appeared. But if the phial was left ſo far charged as juſt to attract a light thread, then if the metal plate were to be touched by the knob of it, even for a moment, it would afterwards, when lifted up, give a ſtrong ſpark, and if then it were to be touched again by the knob of the phial, it would afford a ſecond ſpark hardly ſmaller than the former, and thus ſpark after ſpark may be obtained for a long time, which is a very ſurprizing experiment.

This method of producing ſparks by means of a phial, which is not charged ſo high as to give ſparks of itſelf, is very convenient for various pleaſing experiments; as, for inſtance, that of lighting the inflammable air-piſtol, or lamp, contrived by me, eſpecially when a perſon is provided with one of thoſe phials, prepared after the manner recommended by Mr. TIBERIUS CAVALLO*, which when charged may be carried in the pocket for a long time. Thoſe phials, as they retain a ſenſible charge for ſeveral days, will retain an inſenſible one for weeks or months. I mean, by an inſenſible charge, ſuch as cannot be diſcovered but by the help of the condenſer, in which caſe it becomes more than ſenſible, and ſufficient for the experiment of the inflammable air-piſtol, &c.

25. Secondly, Suppoſe you have an electrical machine ſo badly in order that its conductor will not afford any ſpark, but will juſt attract a thread; then if you let this conductor touch the metal plate of the condenſer, and after ſuffering it to continue in that ſituation for a few minutes, whilſt the machine is kept in motion, lift up the metal plate, you will obtain from it a ſtrong ſpark.

26. Thirdly, In caſe the electrical machine acts very well, but its conductor is ſo badly inſulated, that it will not give any ſparks, as when the conductor touches the walls

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* See his Treatiſe on Electricity.

of the room, or when a chain falls from it upon the table; then if you let the ſaid conductor in that ſtate touch the metal plate of the condenſer, whilſt the electrical machine is in action, the plate will afterwards give ſufficiently ſtrong ſigns of electricity, which ſhews the great power this apparatus has of drawing and condenſing the electricity.

27. Fourthly, The uſual way of rubbing divers bodies, and then preſenting them to an electrometer in order to examine their electricity, is often inſufficient, that is, it makes the experimenter believe, that a body has not acquired any electricity at all, only becauſe the quantity of it is too ſmall to affect an electrometer. In this caſe it is very advantageous to rub thoſe bodies with the metal plate of our apparatus, which plate for this purpoſe muſt be naked; for if the plate be afterwards preſented to an electrometer, this will be electrified conſiderably, however little electricity the rubbed bodies themſelves may have acquired. The quality of this electricity, *viz*. whether it be poſitive or negative, may be eaſily aſcertained, ſince the electricity of the metal plate muſt be the contrary of that acquired by the body rubbed upon it. Mr. CAVALLO alſo made uſe of this method to diſcover the electricity of certain bodies*. But there is a better method, to be uſed in caſe the bodies to be examined are not eaſily adapted to the metal plate, which method neither Mr. CAVALLO nor others have known. This is the following. The metal plate being laid upon the imperfectly conducting plane, the body to be tried is rubbed againſt, or is repeatedly ſtroked, upon it; which done, the plate is taken up, and is examined by an electrometer. If the body tried by this method is a piece of leather, a ſtring, a piece of cloth, or velvet, or other imperfect conductor of the like ſort, the plate will be certainly found electrified, and incomparably more by this means than if it were ſtroked by the ſame bodies, whilſt ſtanding inſulated in the air. In ſhort, by either of thoſe methods you will obtain ſome electricity from ſuch bodies as could hardly be expected to give any, even when they are not very dry. Indeed, coals and metals excepted,

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* See his Treatiſe on Electricity, part IV. chap. VI.

every other body will give ſome electricity. I can farther ſay, that I have often obtained ſome electricity even by ſtroking the metal plate with my naked hand.

28. It has been queſtioned, whether evaporation, fermentation, &c. produced any electricity, and the inveſtigation is of conſequence for determining ſomething certain about the atmoſpherical electricity. I know that various perſons have attempted in vain to diſcover electricity in thoſe caſes. Some experiments of mine relating to this purpoſe had alſo failed; nevertheleſs, I entertained ſome hopes of ſucceeding, as I had for a great while imagined, that effervеſcence, diſſolution, evaporation, &c. by diſturbing the natural form and ſituation of the particles of bodies, ought to have increaſed or diminiſhed the capacity of the bodies contiguous to thoſe in action, and conſequently ought to have occaſioned in ſome caſes a rarefaction, and in others a condenſation of the electric fluid. Being perſuaded of this theory, I thought that the electricity produced in thoſe caſes was not diſcovered, partly becauſe of its ſmall quantity, and partly becauſe the inſulation was almoſt deſtroyed by the vapours that roſe, and I imagined, that by a greater accuracy, and by multiplying the experiments, I ſhould ſome time or other diſcover it *. It is about two years ſince, that having gradually been able to condenſe the electricity to a great degree by means of the above deſcribed apparatus, I again thought of repeating my old experiments about the evaporation, &c. and entertained much better hopes of diſcovering ſomething new about it, almoſt foreſeeing the event; but various occupations deferred thoſe experiments till the months of March and April of the preſent year 1782, when being at Paris, in company with ſome members of the Royal Academy of Sciences, I at laſt ſucceeded in obtaining clear ſigns of electricity, nay and even the ſpark, from the evaporation of water, from the ſimple combuſtion of coals,

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* All theſe thoughts are mentioned in a Latin diſſertation, printed in the year 1769, and entitled, *De vi attractiva ignis elettrici, ac phænomenis inde pendentibus, ad* JOHANNEM BAPTISTAM BECCARIAM, &c.

and from various effervescences, as thoſe which produce inflammable air, fixed air, and nitrous air.

29. I ſhall finiſh the firſt part of this paper with obſerving, that beſides the abovementioned uſes, to which our condenſing apparatus may be applied, the various experiments which may be made with it throw great light upon the theory of electric atmoſpheres in general, of which we are going to treat in the ſecond part.

PART II.

30. The experiments related in the foregoing pages have ſhewn how eaſily a metal plate, or other conducting plain ſurface, when properly ſituated, can draw the electric fluid upon itſelf from a weak atmoſpherical electricity, from a Leyden phial, &c. ſo as to render its effects much more conſpicuous and vigorous. It is now neceſſary to give an explanation of thoſe phenomena, the theory of which will greatly facilitate the practical performance of this ſort of experiments.

31. The whole matter, therefore, may be reduced to this, *viz.* that the metal plate has a much greater capacity for holding electricity in one caſe, *viz.* when it lies upon a proper plane (as mentioned in § 11. 12. 22.) than when it ſtands quite inſulated, as when it is ſuſpended in the air by its ſilk ſtrings or inſulating handle, or when it ſtands upon an inſulating ſtand, as a thick ſtratum of reſin or the like.

32. It is eaſy to comprehend, that wherever the capacity of holding electricity is greater, there the intenſity of electricity

is proportionably leſs, *viz.* a greater quantity of electricity is in that caſe required, in order to raiſe its intenſity to a given degree; ſo that the *capacity* is inverſely as the *intenſity*, by which word I mean the endeavour by which the electricity of an electrified body tends to eſcape from all the parts of it, to which tendency or endeavour the electrical phenomena of attraction, repulſion, and eſpecially the degree of elevation of an electrometer, correſpond.

33. That the *intenſity* of electricity muſt be inverſely proportional to the *capacity* of the body electrified, will be clearly exemplified by the following experiment. Take two metal rods of equal diameter, but one of them a foot, and the other five feet long; and let the firſt be electrified ſo high as that the index of an electrometer annexed to it may be elevated to 60°; then let this electrified rod touch the other rod, and in that caſe it is evident, that the intenſity of the electricity, by being parted between the two rods, will be diminiſhed in proportion as the capacity is increaſed; ſo that the index of the electrometer, which before was elevated to 60°, will now fall to 10°, *viz.* to one-ſixth of the former intenſity, becauſe now the capacity is ſix times greater than when the ſame quantity of electricity was confined to the firſt rod alone. For the ſame reaſon, if the ſaid quantity of electricity was to be communicated to a rod ſixty times longer, its intenſity would be diminiſhed to one degree; and, on the contrary, if the electricity of this long conductor was to be contracted into the ſixtieth part of that capacity, its intenſity would be increaſed to 60°.

34. Now not only conductors of different bulk have different capacities for holding electricity, but alſo the capacity of the ſame conductor may be increaſed or diminiſhed by various circumſtances, ſome of which have not yet been properly conſidered. It has been obſerved, that the capacity of the ſame conductor is increaſed or diminiſhed in proportion as its ſurface is enlarged or contracted, as is ſhewn by Dr. FRANKLIN's experiment of the can and chain, and various other experiments, from which it has been concluded, that the capacity of con-

ductors is in proportion to their ſurface, and not to their quantity of matter.

35. This concluſion is true, but does not comprehend the whole theory, ſince even the extenſion contributes to increaſe the capacity; ſo that of two conductors, which have equal but diſſimilar ſurfaces, that which is the more extended in length has the greater capacity*. In ſhort, it appears from all the experiments hitherto made, that the capacity of conductors is in proportion not to the ſurfaces in general, but *to the ſurfaces which are free*, or *uninfluenced by an homologous atmoſphere*.

36. But that which comes nearer to our caſe is, that the capacity of a conductor, which has neither its form nor ſurface altered, is increaſed when, inſtead of remaining quite inſulated, the conductor is preſented to another conductor not inſulated; and this increaſe is more conſpicuous, according as the ſurfaces of thoſe conductors are larger and come nearer to each other.

When an inſulated conductor is oppoſed or preſented to another conductor whatever, I call it a *conjugate conductor*.

37. The circumſtance mentioned in the preceding paragraph, which augments prodigiouſly the natural capacity of conductors, is that which I find to have been hitherto principally overlooked, far from any advantages having been deduced from it; but let us begin with thoſe experiments which ſhew this increaſed capacity in the ſimpleſt manner. I take, for example, the metal plate of an electrophorus, and holding it by its inſulating handle in the air, electrify it ſo high that the index of an electrometer annexed to it might be elevated to 60°, then lowering this metal plate by degrees towards a table or other conducting plain ſurface, I obſerve that the index of the electrometer falls gradually from 60° to 50°, 40°, 30°, &c. Notwithſtanding this appearance, the quantity of electricity in the plate remains the ſame, except the ſaid plate be brought ſo near the table as to occaſion a tranſmiſſion of the electricity from the

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* See my Diſſertation on the Capacity of Conductors, publiſhed at Milan in the *Opuſcoli Scelti* for the year 1778; and alſo in ROZIER's Journal for the enſuing year.

former to the latter; at leaſt the quantity of electricity will remain as much the ſame as the dampneſs of the air, &c. will permit. The decreaſe, therefore, of intenſity is owing to the increaſed capacity of the plate, which now is not inſulated *ſolitary* but *conjugate*. In proof of this propoſition, if the plate be removed gradually farther and farther from the table, it will be found, that the electrometer riſes again to its former ſtation, namely to 60°, excepting the loſs of that quantity of electricity, which during the experiment muſt have been more or leſs imparted to the air, &c.

38. The reaſon of this phenomenon is eaſily derived from the action of electric atmoſpheres. The atmoſphere of the metal plate, which for the preſent I ſhall ſuppoſe to be electrified poſitively, acts upon the table or other conductor whatever to which it is preſented; ſo that the electric fluid of the table, agreeably to the known laws, retiring to the remoter parts of it, becomes more rare in thoſe parts which are expoſed to the metal plate, and this rarefaction becomes greater the nearer the electrified metal plate is brought to the table. If the metal plate is electrified negatively, then the contrary effects muſt take place. In ſhort, the parts immerſed into the ſphere of action of the electrified metal plate, contract a contrary electricity, which *accidental* electricity, making in ſome manner a compenſation for the *real* electricity of the metal plate, diminiſhes its intenſity, as is ſhewn by the depreſſion of the electrometer (§ 37.).

39. The two following experiments will throw more light upon the reciprocal action of the electric atmoſpheres. Firſt, ſuppoſe two flat conductors, electrified both poſitively or both negatively, to be preſented towards, and to be gradually brought near, each other: it will appear, by two annexed electrometers, that the nearer thoſe two conductors come to each other, the more their intenſities will increaſe; which ſhews, that either of the two *conjugate* conductors has a much leſs capacity now than when it was ſingly inſulated, and out of the influence of the other. This experiment explains the reaſon why an electrified conductor will ſhew a greater intenſity

when it comes to be contracted into a ſmaller bulk; and alſo why a long extended conductor will ſhew a leſs intenſity than a more compact one, ſuppoſing that their quantity of ſurface and of electricity is the ſame; becauſe the homologous atmoſpheres of their parts interfere leſs with each other in the former than in the latter caſe.

40. Secondly, Let the preceding experiment be repeated with this variation only, *viz.* that one of the flat conductors be electrified poſitively, and the other negatively: the effects then will be juſt the reverſe of the preceding, *viz.* the intenſity of their electricities will be diminiſhed, becauſe their capacities are increaſed the nearer the conductors come to each other.

41. Let us now apply the explanation of this laſt experiment to the other experiment mentioned in § 38. *viz.* that of bringing the electrified metal plate towards a conducting plane which is not inſulated; for as this plane acquires a contrary electricity, it follows, that the intenſity of the metal plate's electricity muſt be diminiſhed; hence the annexed electrometer is depreſſed according as the capacity of the plate is increaſed, and conſequently the plate in that caſe may receive a greater quantity of electricity.

42. This matter may be rendered ſtill more clear by inſulating the conducting plane, whilſt the other electrified plate is upon it, and afterwards ſeparating them; for then both the metal plate and the conducting plane (which may be called the *inferior* plane) will be found electrified, but poſſeſſed of contrary electricities, as may be aſcertained by electrometers.

43. If the inferior plane is inſulated firſt, and then the electrified plate is brought over it, then the latter will cauſe an endeavour in the former to acquire a contrary electricity, which, however, the inſulation prevents from taking place; hence the intenſity of the electricity of the plate is not diminiſhed, at leaſt the electrometer will ſhew a very little and almoſt imperceptible depreſſion, which ſmall depreſſion is owing to the imperfection of the inſulation of the inferior plane, and to the ſmall rarefaction and condenſation of the electric fluid, which may take place in different parts of the ſaid inferior

plane. But if in this ſituation the inferior plane be touched ſo as to cut off the inſulation for a moment, then it will immediately acquire the contrary electricity, and the intenſity in the metal plate will be diminiſhed.

44. If the inferior plane, inſtead of being inſulated, were itſelf a non-conducting ſubſtance, then the ſame phenomena would happen, *viz.* the intenſity of the electrified metal plate laid upon it would not be diminiſhed. This, however, is not always the caſe; for if the ſaid inferior non-conducting plane is very thin, and is laid upon a conductor, then the intenſity of the electrified metal plate will be diminiſhed, and its capacity will be increaſed by being laid upon the thin inſulating ſtratum; becauſe in that caſe the conducting ſubſtance, which ſtands under the non-conducting ſtratum, acquiring an electricity contrary to that of the metal plate, will diminiſh its intenſity, &c. and then the inſulating ſtratum will only diminiſh the mutual action of the two atmoſpheres more or leſs, according as it keeps them more or leſs aſunder.

45. The intenſity or electric action of the metal plate, which diminiſhes gradually as it is brought nearer and nearer to a conducting plane not inſulated, becomes almoſt nothing when the plate is nearly in contact with the plane, the compenſation or accidental balance being then almoſt perfect. Hence, if the inferior plane only oppoſes a ſmall reſiſtance to the paſſage of the electricity (whether ſuch reſiſtance is occaſioned by a thin electric ſtratum, or by the plane's imperfect conducting nature, as is the caſe with dry wood, marble, &c.): that reſiſtance joined to the interval, however ſmall, that is between the two planes, cannot be overcome by the weak intenſity of the electricity of the metal plate, which on that account will not dart any ſpark to the inferior plane (except its electricity were very powerful, or its edges not well rounded) and will rather retain its electricity; ſo that, being removed from the inferior plane, its electrometer will nearly recover its former height. Beſides, the electrified plate may even come to touch the imperfectly conducting plane, and may remain in that ſituation for ſome time; in which caſe the intenſity being reduced

almoſt to nothing, the electricity will paſs to the inferior plane exceedingly ſlowly.

46. But the caſe will not be the ſame if, in performing this experiment, the electrified metal plate be made to touch the inferior plane *edgewiſe*; for then its intenſity being greater than when laid flat, as appears by the electrometer, the electricity eaſily overcomes the ſmall reſiſtance, and paſſes to the inferior plane, even acroſs a thin ſtratum *; becauſe the electricity of one plane is balanced by that of the other, only in proportion to the quantity of ſurface which they oppoſe to each other within a given diſtance: whereby when the metal plate touches the other plane in flat and ample contact its electricity is not diſſipated. This apparent paradox is clearly explained by the theory of electric atmoſpheres.

47. What looks more like a paradox is, that neither will the touching the metal plate with a finger, or with a piece of metal, deprive it of all its electricity, whilſt ſtanding upon the proper plane; ſo that it generally leaves it ſo far electrified that, when it is afterwards ſeparated from that plane, it will ſtill afford a ſpark. Indeed this phenomenon could not be explained upon the ſuppoſition that the finger or the metals were perfect conductors. But ſince we do not know of any perfect conductor, the metals or the finger, oppoſe a reſiſtance ſufficient to retard the immediate diſſipation of the electricity of the

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* This explanation, properly applied, renders evident the actions of *points* in general. Properly ſpeaking, a pointed conductor, not inſulated, when preſented to an electrified body, has not in itſelf any particular virtue of attracting electricity. It acts only like a conductor not inſulated, which does not oppoſe any reſiſtance to the paſſage of the electric fluid. If the ſame conductor, inſtead of being pointed, was to preſent a globular or flat ſurface to the electrified body, neither would it in that caſe oppoſe a greater reſiſtance to the paſſage of the electricity. But the reaſon why the electricity will not paſs nearly ſo eaſily from the electrified body to the conductor when it is flat or globular, as when it is pointed, is becauſe in the former caſe the intenſity of the electricity in the electrified body is weakened by the oppoſed flat ſurface, which, acquiring the contrary electricity, compenſates the diminiſhed intenſity incomparably more than a point can. It appears, therefore, that it is not the particular property of a point or of a flat ſurface, but the different ſtate of the electrified body, that makes it part with its electricity eaſier, and from a greater diſtance, when a pointed conducting ſubſtance, than when a flat or globular one is preſented to it.

plate, which is in that caſe actuated by a very ſmall degree of intenſity or endeavour of expanding; ſo that ſuppoſe, for inſtance, that the piece of metal, or the finger by touching the plate, took off ſo much of its electricity as to reduce the intenſity of the remainder to the fiftieth part of a degree; this remaining electricity would then be almoſt nothing; but when the plate, by being ſeparated from the inferior plane, has its capacity ſo far diminiſhed as to render the intenſity of its electricity 100 times greater, then the intenſity of that remaining electricity would become of two degrees or more, *viz.* ſufficient to afford a ſpark.

48. Hitherto we have conſidered in what manner the action of electric atmoſpheres muſt modify the electricity of the metal plate in its various ſituations. We muſt now conſider the effects which take place when the electricity is communicated to the metal plate whilſt ſtanding upon the proper plane. The whole buſineſs having been proved in the preceding pages, it is eaſy to deduce the applications from it; nevertheleſs, it will be uſeful to exemplify it by an experiment. Suppoſe that a Leyden phial or a conductor were ſo weakly electrified that the intenſity of its electricity was only of half a degree or even leſs: if the metal plate of our apparatus, when ſtanding upon the proper plane, was to be touched with that phial or conductor, it is evident, that either of them would impart to it a quantity of its electricity, proportional to the plate's capacity, *viz.* ſo much of it as ſhould make the intenſity of the electricity of the plate equal to that of the electricity in the conductor or phial, ſuppoſe of half a degree; but the plate's capacity, now that it lies upon the proper plane, is above 100 times greater than if it ſtood inſulated in the air, or, which is the ſame thing, it requires 100 times more electricity in order to ſhew the ſame intenſity; therefore, in this caſe it muſt require upwards of 100 times more electricity from the phial or conductor. It naturally follows, that when the metal plate is afterwards removed from the proper plane, its capacity being leſſened ſo as to remain equal to the 100th part of what it was before, the intenſity of its electricity muſt become of 50°; ſince, agree-

ably to the ſuppoſition, the intenſity of the electricity in the phial or conductor was of half a degree.

49. A conductor that is electrified whilſt it ſtands in full and ample contact with another proper conductor, as above ſpecified, and is afterwards ſeparated from it, ſhews the ſame phenomena that are exhibited by a conductor, which, after being electrified, is contracted into a ſmaller bulk, or contrariwiſe, like Dr. FRANKLIN's experiment of the can and chain (§ 35.) &c.

50. If a ſmall quantity of electricity applied to the metal plate of the condenſer enables it to give a ſtrong ſpark, it may be aſked, what would a great quantity of electricity do? The anſwer is, that it would do nothing more, becauſe, when the electricity communicated to the metal plate is ſo ſtrong as to overcome the ſmall reſiſtance of the inferior plane, it will be diſſipated.

51. After all that has been ſaid in the preceding pages, it may be eaſily underſtood, that if the metal plate of our condenſer can receive a good ſhare of electricity from a Leyden phial *, or from an ample conductor, however weakly electrified; it cannot receive any conſiderable quantity of it from a conductor of a ſmall capacity; for this conductor cannot give what it has not, except it were continually receiving a ſtream, howſoever ſmall, of electricity, as is the caſe with an atmoſpherical conductor, or with a prime conductor of an electrical machine, which acts very poorly but continues in action. In thoſe caſes it has been obſerved above (§ 4. 25.) that a conſiderable time is required before the metal plate has acquired a ſufficient quantity of electricity.

52. As an ample conductor, weakly electrified, imparts a conſiderable quantity of electricity to the metal plate of our

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* In my Paper on the Capacity of ſimple Conductors is ſhewn the great capacity of a Leyden phial in compariſon to its bulk, juſt becauſe the electricity, which is communicated to one of its ſurfaces, is balanced by the contrary electricity of the oppoſite ſurface. There I ſhew, that the capacity of 16 ſquare inches of coated ſurface is equal to the capacity of a conductor made of ſilvered cylindrical ſticks, and nearly 100 feet long, the capacity of which is ſo great that its ſpark occaſions a ſhock conſiderably ſtrong.

condenſer, ſo that when the ſaid metal plate is afterwards ſeparated from its proper plane, the electricity in it appears much condenſed and vigorous; ſo when the ſame metal plate contains a ſmall quantity of electricity, and ſuch as cannot give a ſpark or affect an electrometer, that electricity may be rendered very conſpicuous by communicating it to another ſmall metal plate or condenſer.

Mr. CAVALLO was the firſt who thought of this improvement, which he derived by reaſoning upon my experiments. He actually made a ſmall metal plate not exceeding the ſize of a ſhilling: this ſecond condenſer is certainly of great uſe in many caſes, in which the electricity is ſo ſmall as not to be at all, or not clearly, obſervable by my method or a firſt condenſer only, as has been evidently proved by ſome experiments we made together. Sometimes the uſual metal plate of my condenſer acquired ſo ſmall a quantity of electricity, that being afterwards taken up from the inferior plane, and preſented to an extremely ſenſible electrometer of Mr. CAVALLO's conſtruction, it did not affect it. In this caſe, if the ſaid metal plate, thus weakly electrified, was made to touch the other ſmall plate properly ſituated, and that was afterwards brought near an electrometer, the electricity was then generally ſtronger than what would have been ſufficient to aſcertain its quality.

Now, if by the help of both condenſers the intenſity of the electricity has been augmented 1000 times, which is by no means an exaggeration, how weak muſt then be the electricity of the body examined? how ſmall muſt that electricity be which is produced by rubbing a piece of metal with one's hand, ſince when this electricity is condenſed by both condenſers, and then is communicated to an electrometer, it can hardly affect that inſtrument? Yet it is ſufficient to afford conviction, that the metal can be electrified by the friction of a perſon's hand. Some years ago, *viz.* before the diſcovery of our condenſer, and of Mr. CAVALLO's ſenſible electrometer, we were very far from being able to diſcover ſuch weak excitations; whereas, at preſent, we can obſerve a quantity of electricity incomparably ſmaller than the ſmalleſt obſervable at thoſe times.

A P P E N D I X.

IN § 28. I mentioned, that after various attempts I at laſt ſucceeded in obtaining undoubted ſigns of electricity from the ſimple evaporation of water, and from various chemical efferveſcences; but as this is a fact not leſs intereſting than new, it ſeems proper to ſubjoin in this place a faithful account of the experiments made for that purpoſe. The firſt ſet of experiments were made at Paris, in company with Mr. LAVOISIER and Mr. DE LA PLACE, two intelligent philoſophers and members of the Royal Academy of Sciences. After I had ſhewn them my experiments with my condenſer, they, as well as myſelf, began to entertain hopes of ſucceeding in the experiments on the evaporation, &c. Accordingly Mr. LAVOISIER ordered a large condenſer with a marble plane to be made. The firſt experiment I attempted with this inſtrument, in company with Mr. DE LA PLACE, proved unſucceſsful; but the weather at that time was bad, the room was narrow and full of vapours, and the apparatus was not quite in proper order. Mr. DE LA PLACE and Mr. LAVOISIER repeated thoſe experiments in the country, and then they were attended with ſucceſs, which incited us to repeat and diverſify the experiments, by which means the diſcovery was compleated; having obtained unequivocal ſigns of electricity from the evaporation of water, from the ſimple combuſtion of coals, and from the efferveſcence of iron filings in diluted vitriolic acid. This obſervation was made the 13th of April of the preſent year 1782, and the experiments were performed in the following manner. In an open garden a long metal plate was inſulated, which, by means of a large iron wire, was made to communicate with the metal plate of the condenſer laid upon the piece of

marble,

marble, which was kept continually warm by ſome lighted coals ſet underneath. This done, ſome chafing-diſhes, containing burning charcoal, were placed upon the large inſulated plate. The combuſtion of the coals was helped by a gentle wind. Some minutes after, the iron wire, by which the large inſulated plate was connected with the metal plate of the condenſer, was taken off; then the metal plate being removed from the marble by its inſulated handle, and preſented to Mr. CAVALLO's electrometer, made the balls of it diverge with negative electricity. The experiment was repeated by placing upon the large inſulated plate four veſſels, containing iron filings and water, inſtead of the chafing-diſhes: then ſome vitriolic acid was poured into thoſe four veſſels, ſufficient to cauſe a vigorous efferveſcence, and when the ſtrongeſt ebullition was going to ſubſide, the metal plate of the condenſer was removed from over the marble; and being examined, not only electrified the electrometer with negative electricity, but gave a ſenſible ſpark. At this time having tried to obtain electricity from the evaporation of water, the effects were equivocal or hardly ſenſible; the ſame thing happened a few days after, when however we obtained clear ſigns of electricity from thoſe effervescences, which produce fixed and nitrous air. Thoſe experiments were made in a large room.

One day the electricity ariſing from the evaporation of water ſeemed to be poſitive; but ſubſequent experiments, and other circumſtances, indicate that ſuch a phenomenon muſt be attributed to a miſtake.

Once on repeating theſe experiments in company with Mr. LE ROY, member of the R. A. of Sciences, we could not obtain any electricity from the evaporation of water or from combuſtion, the weather being extremely damp; but the effervescence of iron filings and diluted vitriolic acid produced electricity enough to aſcertain that it was negative, though it afforded no ſpark.

A ſhort time before I left Paris I once more repeated the experiment of the effervescence of iron filings, &c. with ſucceſs. This experiment was made in the laboratory of Mr. BILLAUM, an inſtrument-maker and lover of electricity.

The experiment on the evaporation of water, which did not anſwer ſo well at Paris, ſucceeded much better in London, where I bethought me of throwing water upon the lighted coals, which were kept in an inſulated chafing-diſh. In this manner the electricity of the evaporation never fails to electrify the chafing-diſh negatively, and ſtrongly enough for the electricity to be diſcovered by the ſimple electrometer; it will even afford a ſpark, if the condenſer is uſed. The firſt experiment of this ſort was made at Mr. BENNET's, who is a great lover of electricity, in preſence of Mr. BENNET, Mr. CAVALLO, and Mr. KIRWAN, members of the Royal Society, and of Mr. WALKER, lecturer of experimental philoſophy.

Another time this experiment was repeated with ſucceſs at Mr. CAVALLO's, in the following manner. A ſmall crucible, containing three or four ſmall coals lighted, was inſulated; then a ſpoonful of water was thrown upon the coals, and immediately after an electrometer, which communicated with the coals by means of a wire, diverged with negative electricity.

Theſe are the experiments which I have had the opportunity to make hitherto; in relating which I muſt not omit to obſerve, that although the condenſing apparatus has not been always indiſpenſably neceſſary, Mr. CAVALLO's very ſenſible electrometer alone having been often ſufficient for the purpoſe; yet it muſt be confeſſed, that it was the condenſing apparatus which ſuggeſted theſe experiments, and by the help of which even the electric ſpark could be obtained. Theſe experiments have juſt opened the way to a vaſt field, which deſerves much farther inveſtigation. It is natural to ſuppoſe, that if compact bodies, when they are rarefied or become an elaſtic fluid, require an additional quantity of electric fluid, and conſequently leave thoſe bodies, with which they are connected, negatively electrified; it muſt happen, on the contrary, that when vapours condenſe they muſt part with ſome electric fluid, that is, muſt produce a poſitive electricity. This, however, remains to be proved experimentally, and I have already imagined ſeveral ways of trying it, which will be put in practice as ſoon as I ſhall have the opportunity. Mean while I beg leave to conclude this paper with mentioning a few ideas I entertain relating to the atmoſpherical electricity.

The experiments hitherto made, though not numerous, yet concur to ſhew, that the vapours of water, and in general the parts of all bodies, that are ſeparated by volatilization, carry away an additional quantity of electric fluid as well as of elementary heat, and conſequently that thoſe bodies, from the contact of which the volatile particles have been ſeparated, remain both cooled and electrified negatively: from which it may be deduced, that whenever bodies are reſolved into volatile elaſtic fluid, their capacity for holding electric fluid is augmented, as well as their capacity for holding common fire, or the calorific fluid. This is a ſtriking analogy by which the ſcience of electricity throws ſome light upon the theory of heat, and alternately derives light from it; I mean on the doctrine of latent or ſpecific heat, the firſt notions of which were ſuggeſted by the admirable experiments of Dr. BLACK and WILKE, and which has been afterwards much elucidated by Dr. CRAWFORD, who followed the experiments of Dr. IRWIN.

By following this analogy it ſeems, that as the vapours on their condenſing, loſe part of their latent heat, on account of their capacity being diminiſhed, ſo they part with ſome electric fluid. Hence originates the poſitive electricity, which is always more or leſs predominant in the atmoſphere, when the ſky is clear, *viz.* at that height where the vapours begin to be condenſed. Accordingly, the atmoſpherical electricity is ſtronger in fogs, in which caſe the vapours are more condenſed, ſo as to be almoſt reduced into drops, and is ſtill ſtronger when thick fogs become clouds.

Hitherto we have accounted for the poſitive atmoſpherical electricity; but it is eaſy to account for clouds negatively electrified; for when a cloud, poſitively electrified, has been once formed, its ſphere of action is extended a great way round, ſo that if another cloud comes within that ſphere, its electric fluid, agreeably to the well known laws of electric atmoſpheres, muſt retire to the parts of it which are the remoteſt from the firſt cloud; and from thence the electric fluid may be communicated to other clouds, or vapours, or terreſtrial prominencies. Thus a cloud may be electrified negatively, which cloud, after the ſame manner, may occaſion a poſitive electricity in another cloud, &c. This explains not only the negative electricity, which is often obtained from the atmoſphere in cloudy weather; and the frequent changes from poſitive to negative electricity, and contrariwiſe in ſtormy weather; but alſo the waving motion often obſerved in the clouds, and the hanging down of them, ſo as nearly to touch the earth.

After the fore-mentioned diſcoveries we need no longer wonder at the appearance of lightnings in the eruptions of volcanos, as was particularly obſerved in the late dreadful eruption of Mount Veſuvius. The few experiments I have made ſhew, that the quantity of ſmoke, but much more the rapidity with which it is produced, tends to increaſe the electricity which ariſes from combuſtion, &c. How great muſt then be the quantity of electricity that is produced in ſuch eruptions?

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